3.0 RESULTS

3.1 WEATHER AND OCEANOGRAPHIC CONDITIONS

3.1.1 Weather

The caged mussel and SPMD exposures occurred over a 57-58 day period from February 21 through April 23. During this time, several winter storms passed through the eastern portion of the Santa Barbara Channel, causing high winds, swell, and rainfall with associated stormwater runoff within the study area. The timing and magnitude of the storm events are illustrated with plots of wind speed and rainfall amounts (Figure 3.1-1). Wind velocity and rainfall data from a land-based station in Santa Barbara (data were obtained from Western Regional Climate Center, Reno, NV) show that several storm events, with measurable rainfall, occurred during February 24 and 27, March 14-15, and April 13-14. Data from NDBC Buoy 46053, located approximately 12 nmi southwest of Santa Barbara (http//www.nodc.noaa.gov/BUOY/46053.html), showed an average wind velocity of 5 m/sec (approximately 10 knots based on 3-hour low pass filtered data), with maximum wind velocity of 16 m/sec (approximately 32 knots) during the study period. Significant wave height (i.e., the average height of highest one-third of all waves during a 20-minute sampling period) averaged 1.5 m, with a maximum significant wave height of 3.6 m.

The most significant storm event occurred around March 15, when approximately 12 cm of rainfall occurred at Santa Barbara within a 24-hour period. Wind velocities at Buoy 46053 increased to 30 knots, and significant wave heights increased, coinciding with a decrease in surface water temperatures at the buoy of least 2 ˚C over a period of one to two days.

These storm events affected the direction of near-bottom currents and water temperatures in the vicinity of the shell mound and reference sites (see Section 3.1.2).

3.1.2 Currents

Table 3.1-1 lists the mean, maximum, and minimum bottom current velocities, as well as the orientation of principal current axes at the shallow and deep sites. These values are based on 40-hour low pass filtered data. The mean and maximum current speeds at the deeper mooring site (9.8 and 34 cm/s) were higher than those at the shallow site (6.8 and 29 cm/s). The principal current axes at the shallow (SBSM-1) and deep (SBSM-2) sites were oriented towards 281 and 261 degrees true (i.e., towards the west or upcoast from the shell mound sites). The 20 degree difference in the primary axis directions at the shallow and deep mooring sites were likely due to effects of the local bathymetry. These results were consistent with circulation patterns in the Santa Barbara Channel described by Harms and Winant (1998).

Current direction and speed for the shallow and deep sites are shown as a time series of stick plots in Figure 3.1-2. The orientation of the individual tick marks reflect the

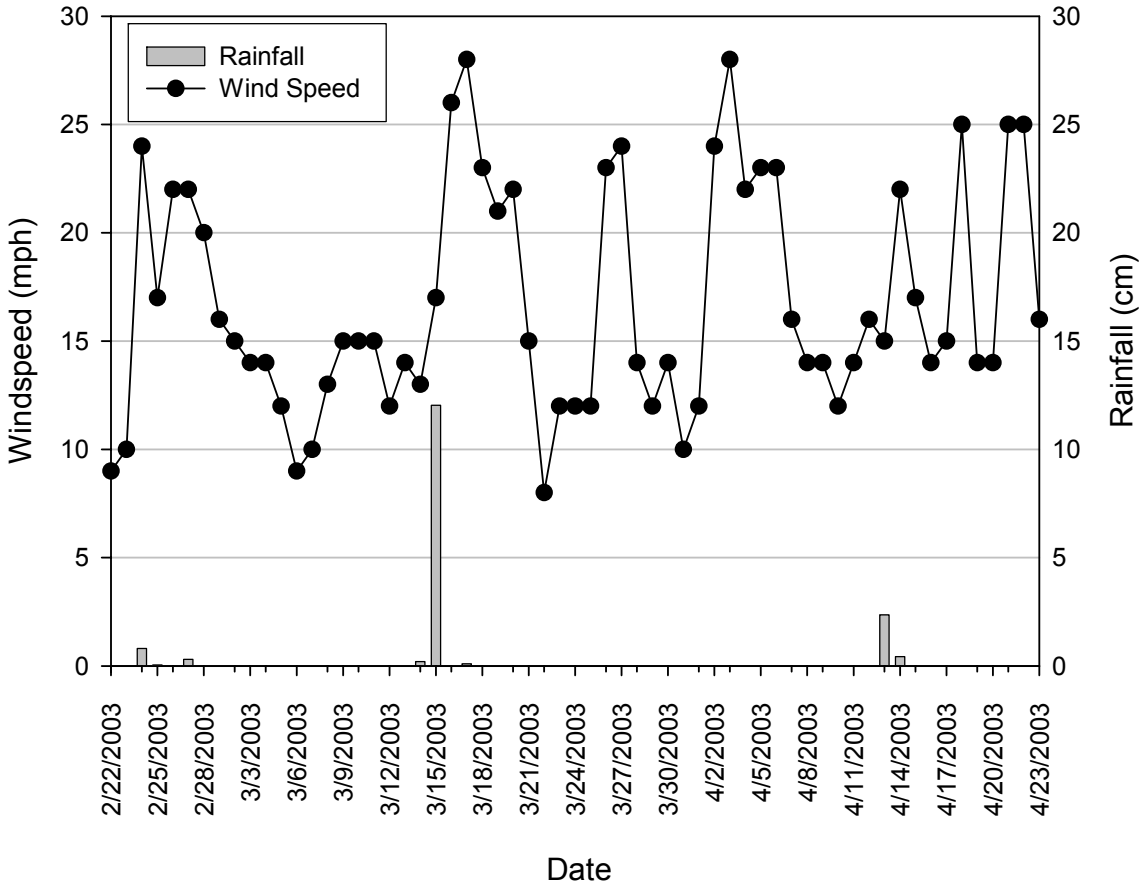

Figure 3.1-1. Daily Rainfall (cm) and Maximum 2-Minute Wind Speeds in Santa Barbara, CA During February 22 to April 23, 2003
(Data were obtained from the Western Regional Climate Center.)

Table 3.1-1. Summary of Current Data for Shallow and Deep Moorings During February 22 to April 27, 2003

	DEPTH (M)		CURRENT SPEED (CM/S)			DIRECTION (˚T)	
	Instrument	*Bottom*	*Max.*	*Min.*	*Mean*	*Vector*	*Predominant Axis*
Shallow	26	33	28.9	0.2	6.82	303	281
Deep	32	39	34.4	0.2	9.81	298	261
Note: The mean vector represents an average of current speed and direction, and the predominant axis is the orientation of the major axis of the current variance.							

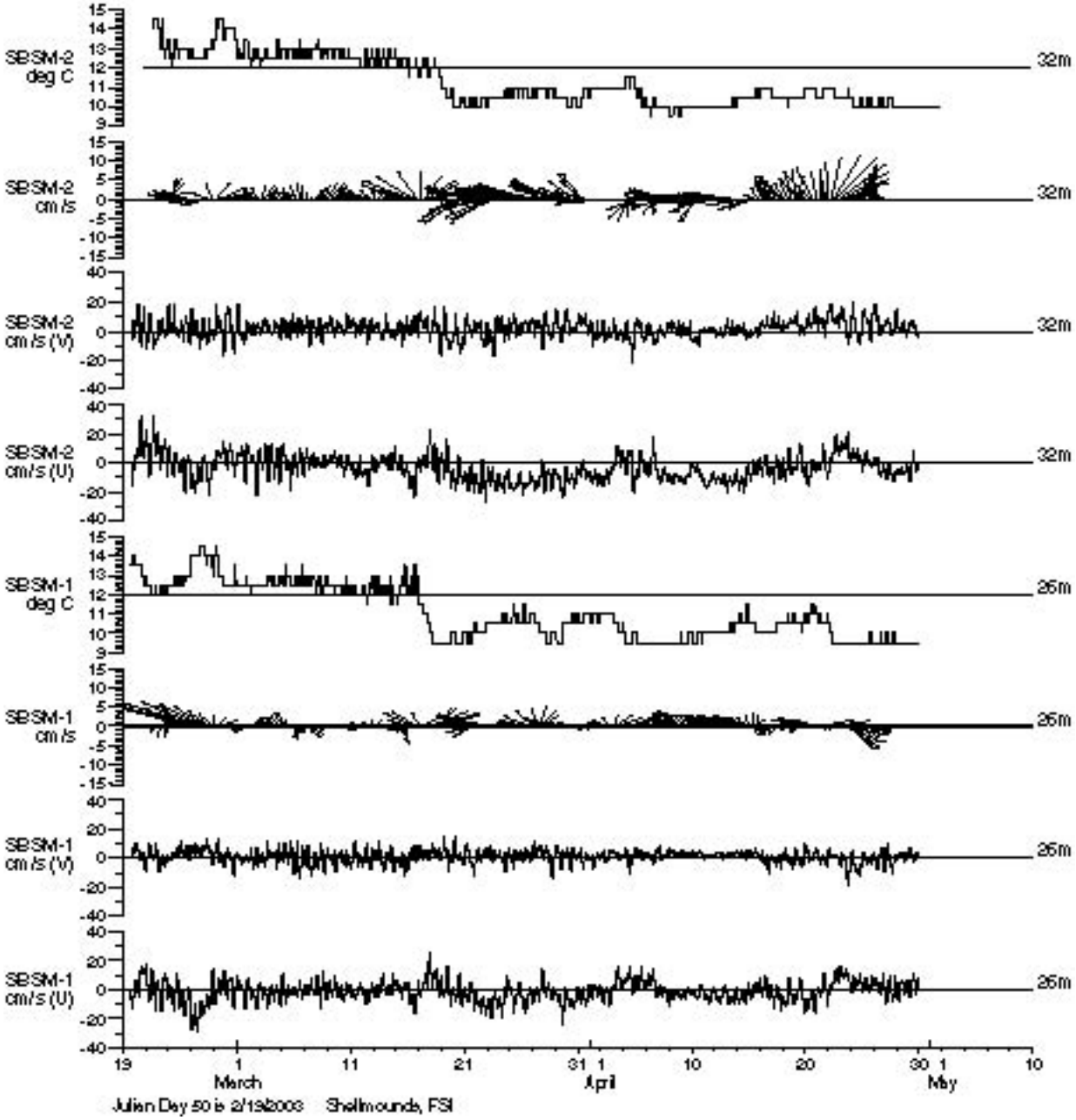

Figure 3.1-2. Times Series of Currents and Water Temperatures at the Deep (SBSM-2) and Shallow (SBSM-1) Current Meter Moorings

(Data are 40-hour low pass filtered. Water temperatures are degrees centigrade, and current velocities are cm/s. Stick plots represent the speed and direction of currents; current velocities are proportional to the length of the stick, and orientation represents the direction of current movement. True north is straight up.)

direction of water movement, and the length of the tick mark is proportional to the current velocity. The current vectors are based on 40-hour low pass filtered data and they do not reflect tidal and other higher frequency variability, which accounted for approximately 50% of the kinetic energy of the currents.

Currents at the shallow and deep sites generally were in agreement, except near the end of the deployment period when current directions appear to diverge. Currents at both sites were mostly oriented in directions that were parallel to the local isobaths (i.e., depth contours) in both upcoast and downcoast directions (Figure 3.1-3), and showed a high coherence at the diurnal and semi-diurnal periods (Figure 3.1-4). The dominant tidal component (M2) also showed good agreement between the two sites. During storm events, the current directions appeared to change, whereas current speeds did not exhibit any obvious increases, although some of this variability may have been removed by the data filter.

3.1.3 Water Temperature

The water temperature records at the shell mound and reference sites exhibited similar temporal trends. Average temperatures for near-bottom waters at all shell mound and reference sites ranged from 11.1 to 12.1 ˚C, with an overall range of 9.9 to 15.1 ˚C. Figures 3.1-5 and 3.1-6 are plots of the temperatures and currents at the deep and shallow mooring sites along with the Buoy 46053 winds and significant wave height measurements. The cooling event during March 17-18 was evident at all sites. Another drop in bottom water temperatures occurred on or about April 1. It is likely that the lower water temperatures following these storm events resulted from regional upwelling of colder, deep waters onto the nearshore portions of the eastern Santa Barbara Channel.

3.2 CAGED MUSSEL BIOASSAY

3.2.1 Mussel Survival

Survival by individual cage ranged from a low of 87.3% at the shallow reference site to a high of 96.4% at both the shallow reference and deep reference sites. Mean survival by site ranged from 90% at the Hazel shell mound to 93% at the deep reference site (Table 3.2-1). The small variance in survival at each site was somewhat surprising, particularly given the high possibility of predation by crabs and starfish and the predicted presence of a suspended layer of fine sediments and flocculants with potentials to smother and kill the test animals. However, there was no difference among sites in survival based on results of the Simes Multiple Comparison Test.

3.2.2 Growth

Mussel growth metrics data are summarized in Table 3.2-2, and results of all statistical analyses performed on the mussel growth metrics are summarized in Table 3.2-3. Considering all growth metrics, mussel growth was highest at the Hilda shell mound and

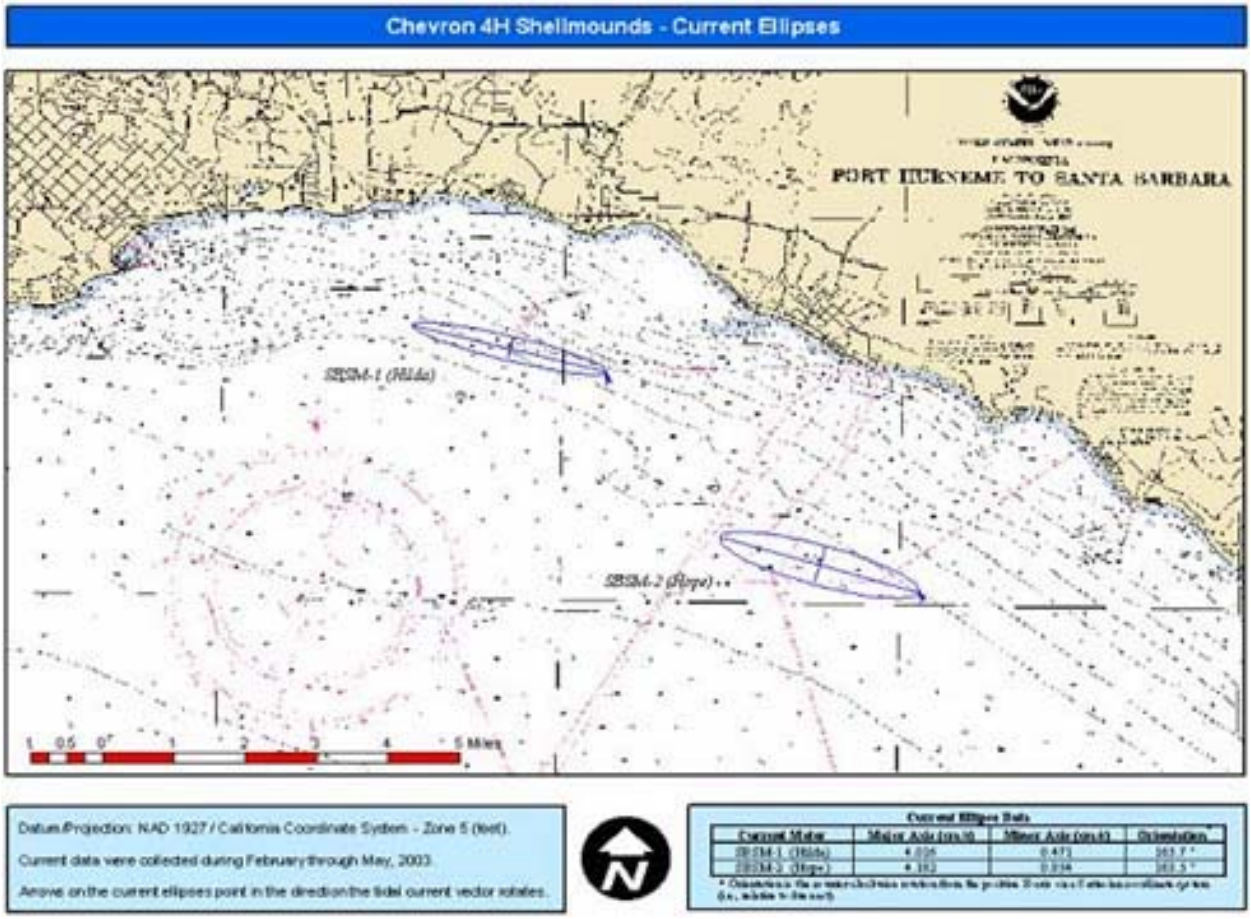

Figure 3.1-3. Current Ellipses for the Tidal Component (M2 Lunar Tide) at the Shallow (SBSM-1) and Deep (SBSM-2) Current Meter Moorings

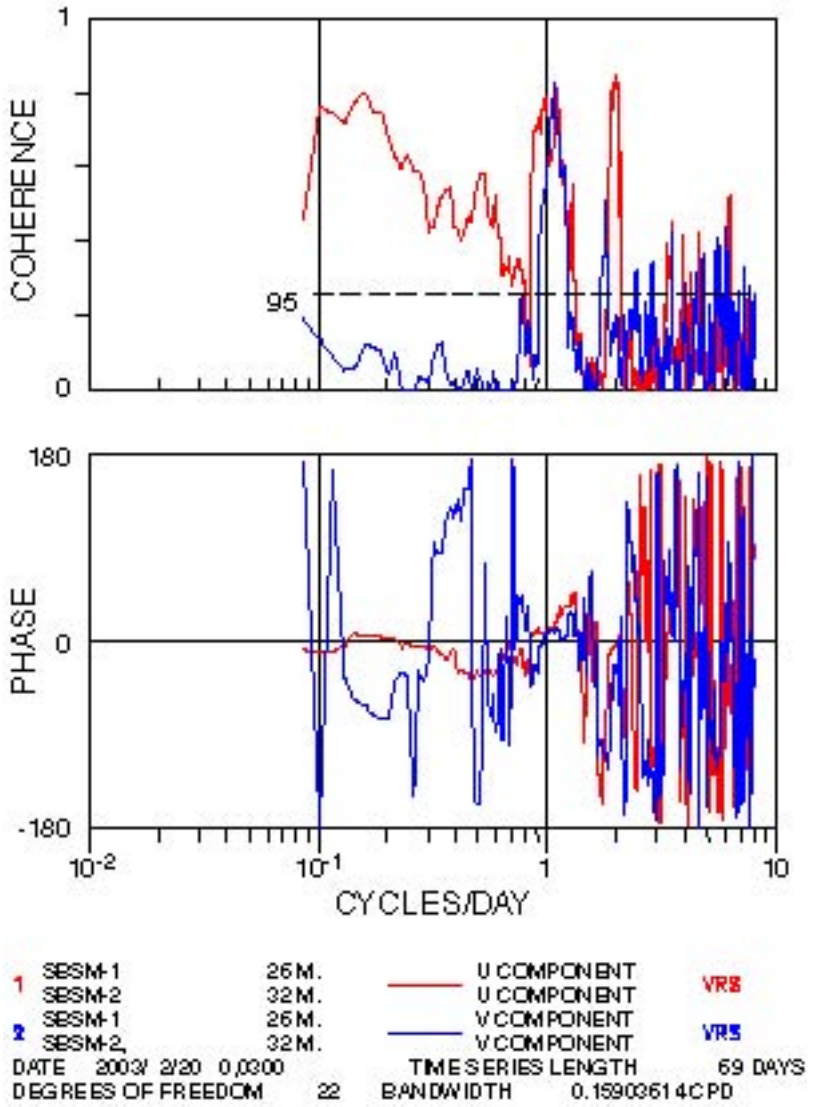

Figure 3.1-4. Coherence and Phase of Currents at the Shallow (SBSM-1) and Deep (SBSM-2) Current Meter Moorings

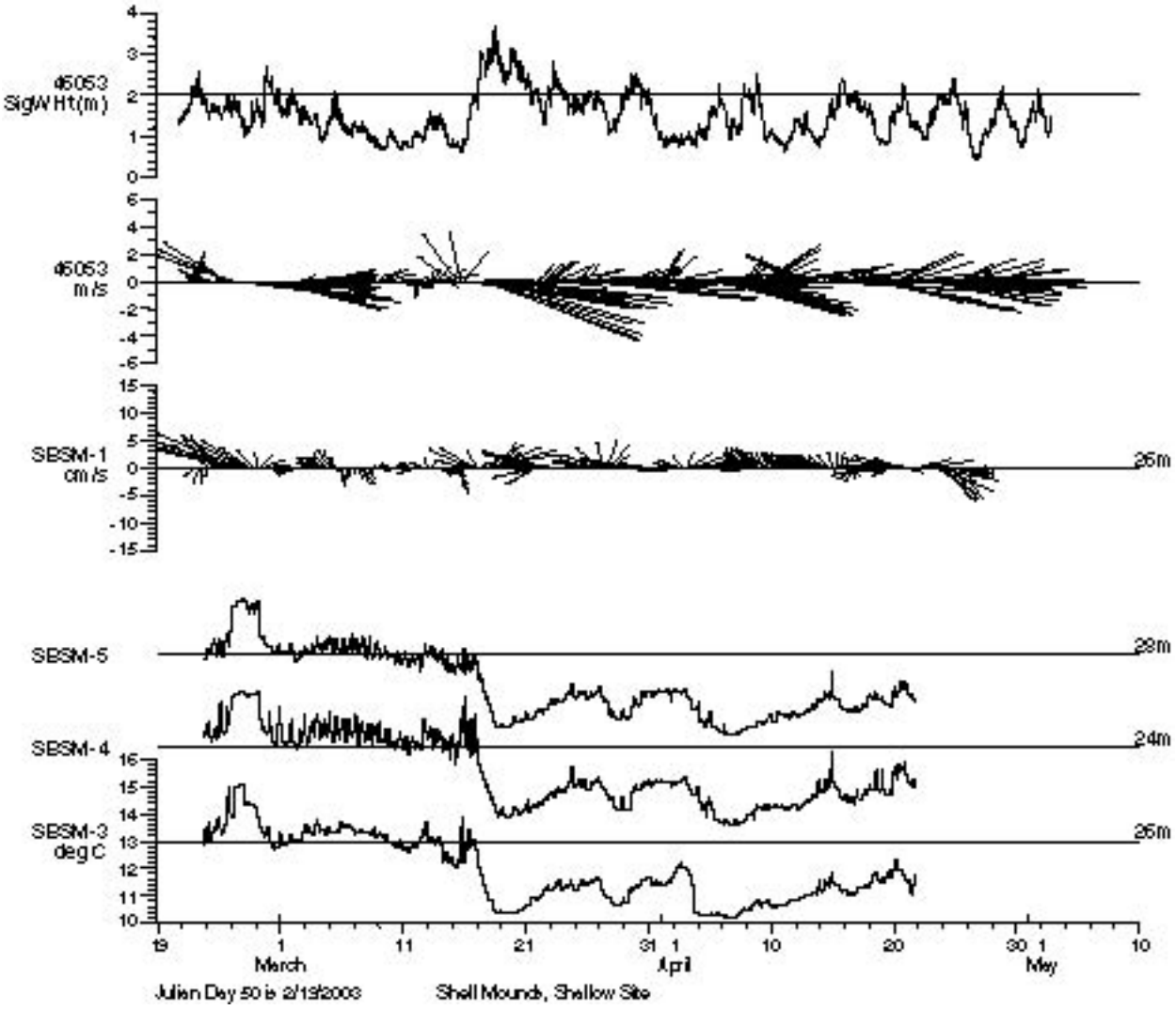

Figure 3.1-5. Comparisons of Time Series for Significant Wave Height (m) and Wind Velocity (m/s) at NDBC Buoy 46053, Currents at Shallow Current Mooring (SBSM-1), and Water Temperatures at the Shallow Shell Mound and Reference Sites (Note that a significant cooling event occurs around March 17 and coincides with large waves and changes in wind direction.)

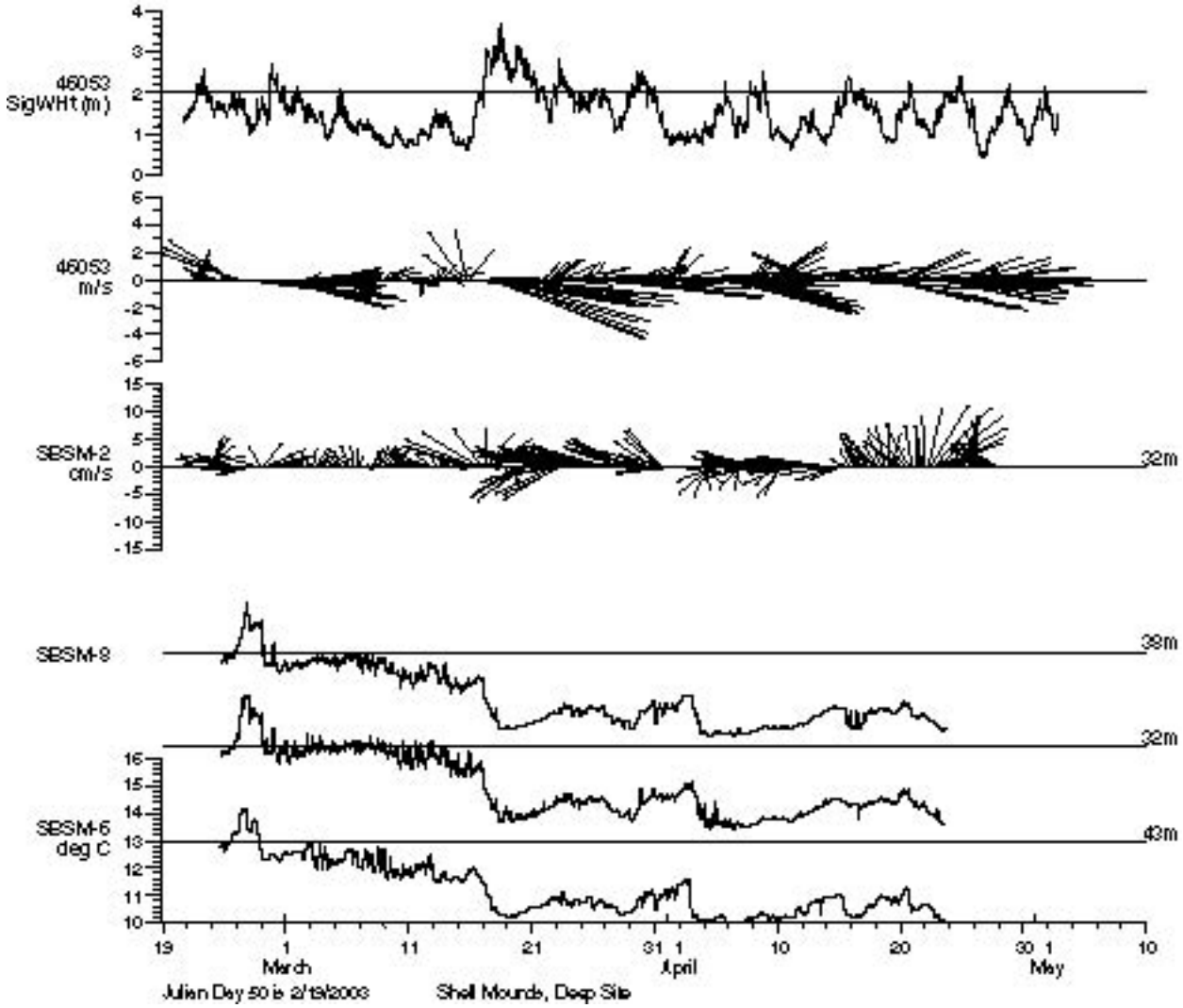

Figure 3.1-6. Comparisons of Time Series for Significant Wave Height (m) and Wind Velocity (m/s) at NDBC Buoy 46053, Currents at Deep Current Mooring (SBSM-2), and Water Temperatures at the Deep Shell Mound and Reference Sites

Table 3.2-1. Percent Survival by Individual Cage and Mean by Site

DEPLOYMENT SITE						
Sample	*Hazel*	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*Deep Ref*
Cage 1	NR	90.9%	87.3%	94.5%	92.7%	96.4%
Cage 2	89.1%	94.5%	NR	90.9%	90.9%	94.5%
Cage 3	90.9%	94.5%	92.7%	92.7%	NR	92.7%
Cage 4	na	na	96.4%	na	na	89.1%
Average	**90.0%**	**93.3%**	**92.1%**	**92.7%**	**91.8%**	**93.2%**
NR – not recovered; na – not analyzed						

lowest at the deep reference site. Based on EOT tissue weights only, growth was highest at the Hilda and Hazel shell mounds, the two shallow mound sites, and lowest at the deep reference site.

Shell Length

Shell lengths for individual BOT mussels ranged from 47.0 to 55.7 mm, and there were no significant differences among individual cages ($p = 1.000$) or among sites ($p = 1.00$) in mean shell lengths. Mean shell length increased at all stations during the exposure period. EOT shell lengths for individual mussels ranged from 47.8 to 64.0 mm (Table 3.2-2). Mean EOT shell length by site ranged from 54.8 mm at the Hope shell mound to 55.9 mm at the Hilda shell mound (Figure 3.2-1a). The mean percentage increase in shell length across sites ranged from 6.7% at Hope to 9.0% at Hilda (Figure 3.2-1b). There was a significant increase in shell length at all sites ($p < 0.0001$), with an average increase in shell length across all sites of approximately 4 mm. In contrast, there was no significant difference in EOT shell length among the shallow sites ($p = 0.4425$) or deep sites ($p = 0.0879$).

EOT length growth rates by sites ranged from 0.42 mm/wk at the Hope shell mound to 0.55 mm/wk at the Hilda shell mound (Figure 3.2-1c). There was no significant difference ($p = 0.2651$) in length growth rates among the shallow shell mounds and shallow reference sites ($p = 0.2651$). Length growth rates were significantly higher at the Heidi shell mound compared to the deep reference site ($p = 0.0087$), whereas there was no difference between the Hope shell mound and the deep reference site.

Whole-Animal Wet-Weight (WAWW)

Mean BOT WAWW by site ranged from 12.11 to 12.58 g (Table 3.2-2), and there was no significant difference among individual cages ($p = 0.991$) or among sites ($p = 0.386$).

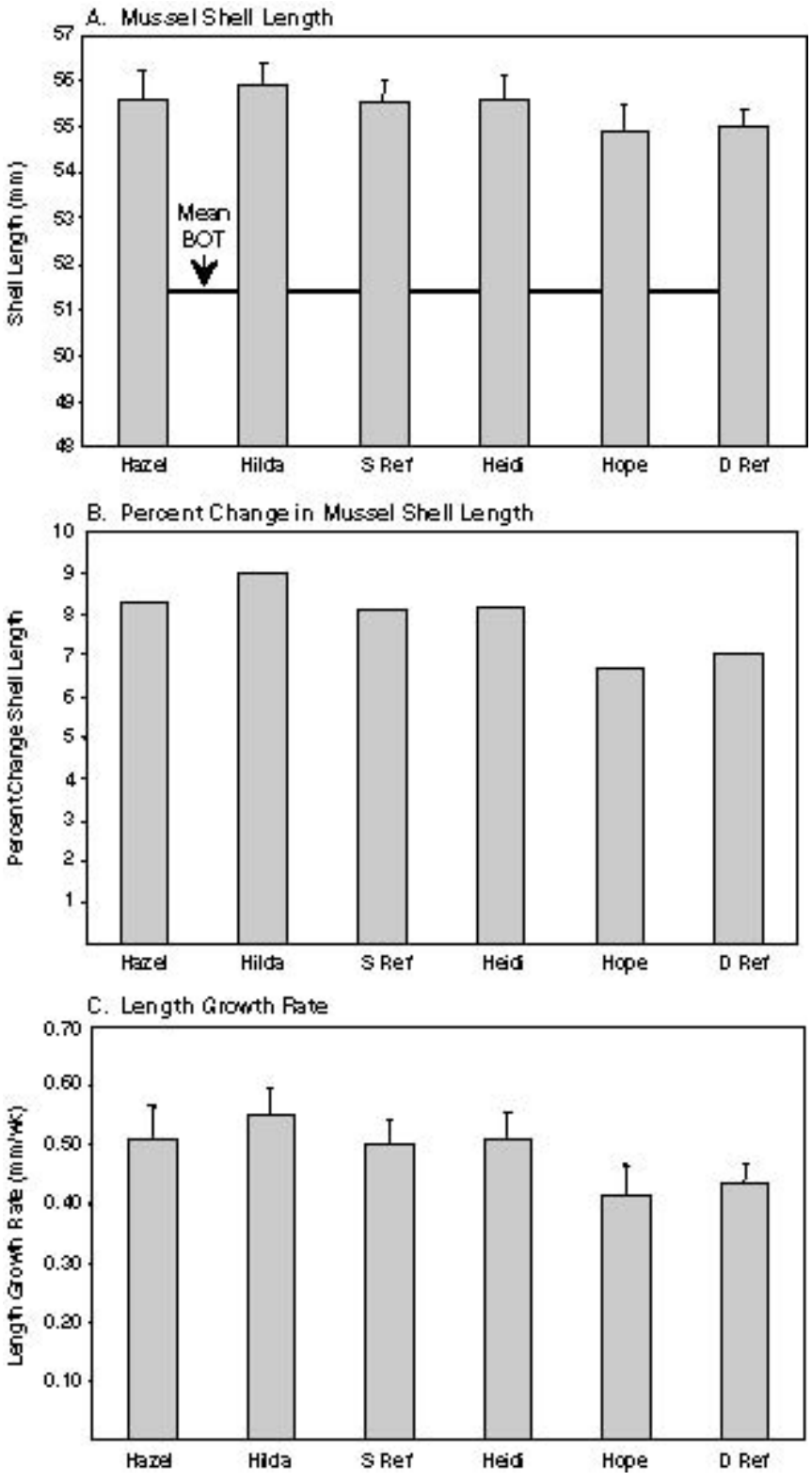

Figure 3.2-1. Mussel Length Metrics

Mean WAWW increased at all stations during the exposure period. EOT WAWWs for individual mussels ranged from 9.54 to 24.73 g (Table 3.2-2). Mean EOT WAWW by site ranged from 15.18 g at the deep reference site to 16.46 g at the Hilda shell mound (Figure 3.2-2a). The mean percentage increase in WAWW across sites ranged from 23.9% at the deep reference site to 31.3% at the Hilda shell mound (Figure 3.2-2b).

There was a significant increase in WAWW at all stations ($p < 0.0001$), with an average increase across all stations of approximately 3.4 g. At the shallow sites, EOT WAWW was significantly higher at Hilda ($p = 0.0114$) when compared to the shallow reference site and when compared to all sites. At the deep sites, EOT WAWW was significantly higher at the Heidi shell mound ($p = 0.0490$) when compared to the deep reference site.

EOT WAWW growth rates by station ranged from 346 mg/wk at the deep reference site to 466 mg/wk at the Hilda shell mound (Figure 3.2-2c). There was no significant difference ($p = 0.2188$) in WAWW growth rates among the shallow sites or between the shallow shell mound and reference sites ($p = 0.2188$). WAWW growth rates were significantly higher at the Heidi shell mound when compared to the deep reference site ($p = 0.0004$) and when all sites were compared against each other ($p = 0.0004$). There was no significant difference between the Hope shell mound and deep reference site.

Wet Tissue Weights

Mean whole soft tissue weight at the start of the test was estimated at 3.23 g-wet (Table 3.2-2) based on the tissue weights from the 165 baseline BOT measurements. Based on this estimated BOT value, mean whole soft tissue weights increased at all sites during the exposure period. Mean EOT wet tissue weights by site ranged from 3.30 g-wet at the deep reference site to 4.78 g-wet at the Hilda shell mound (Figure 3.2-3a). The percentage change in wet tissue weight across sites ranged from 2.0% at the deep reference site to 47.7% at the Hilda shell mound (Figure 3.2-3b).

There was a significant increase in tissue weight at all sites except the deep reference site ($p < 0.0001$) when compared to the BOT tissue weights. EOT tissue weights were significantly higher at both the Hazel and Hilda shell mounds ($p < 0.0001$) when compared to the shallow reference site, whereas there was no significant difference between the Hazel and Hilda shell mounds. Similarly, EOT tissue weights were significantly higher at both the Heidi and Hope shell mounds ($p < 0.0001$) when compared to the deep reference site, but there was no significant difference between Heidi and Hope shell mounds.

Shell Weight

Mean shell weight at the start of the test was estimated at 4.66 g-wet (Table 3.2-2) based on the shell weights from the 165 baseline BOT measurements. Based on this estimated BOT value, mean shell weights increased at all sites during the exposure period. Mean EOT shell weights by site ranged from 5.23 g-wet at the deep reference site to 5.70 g-wet at the Hilda shell mound (Figure 3.2-4a). The percentage change in

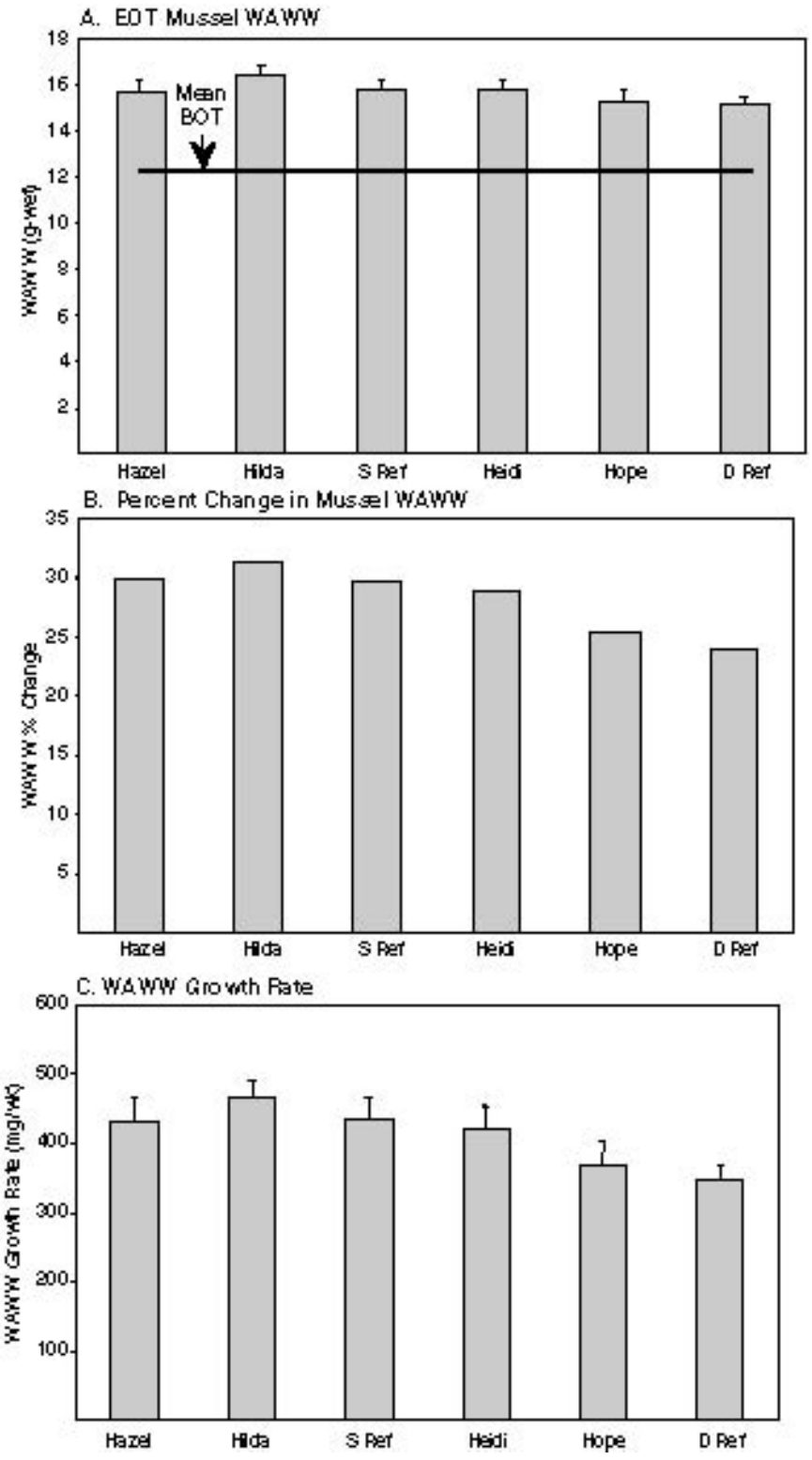

Figure 3.2-2. Mussel Whole Animal Wet Weight (WAWW) Metrics

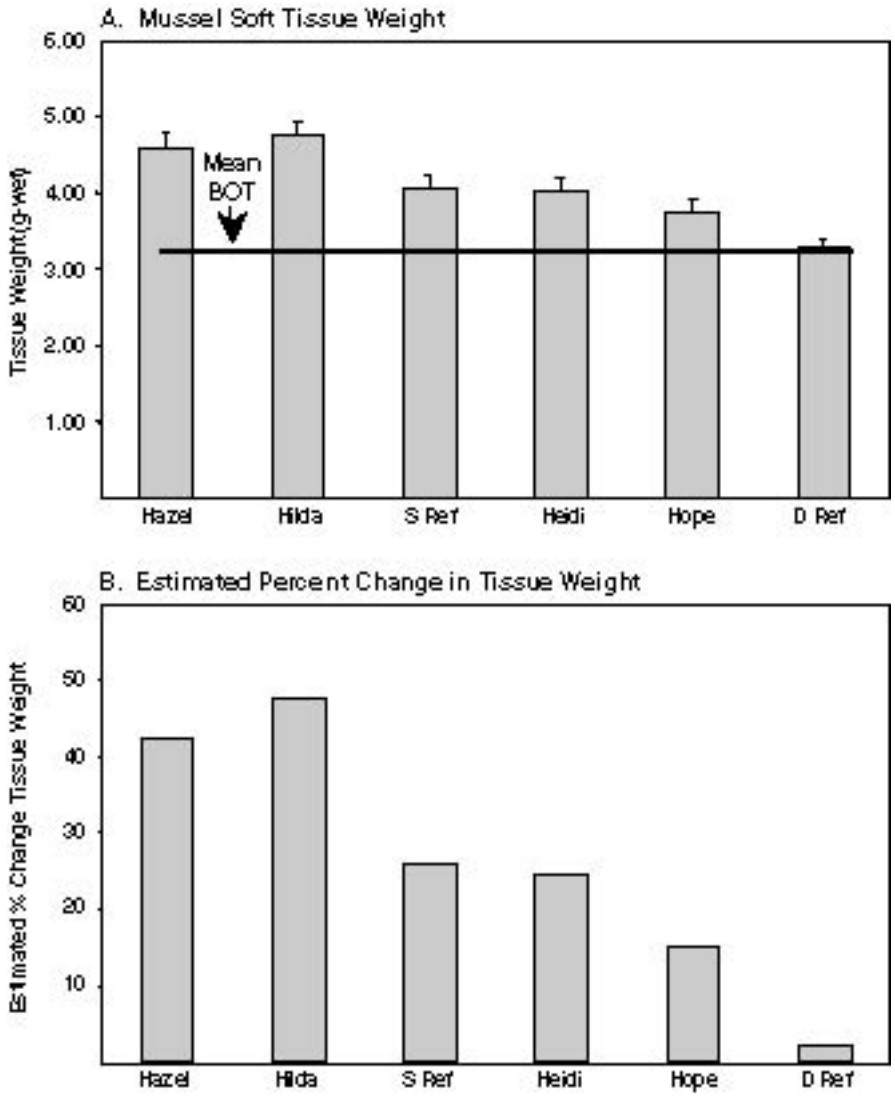

Figure 3.2-3. Mussel Soft Tissue Weights

shell weight across sites ranged from 12.2% at the deep reference site to 22.3% at the Hilda shell mound (Figure 3.2-4b).

There was a significant increase in shell weight at all sites ($p < 0.0001$) when compared to the BOT shell weights. There was no significant difference in EOT shell weights at the shallow shell mounds compared to the shallow reference site or when all sites were compared. EOT shell weights were significantly higher ($p = 0.0090$) at the Heidi shell mound when compared to the deep reference site, whereas there was no significant difference between the Heidi and Hope shell mounds.

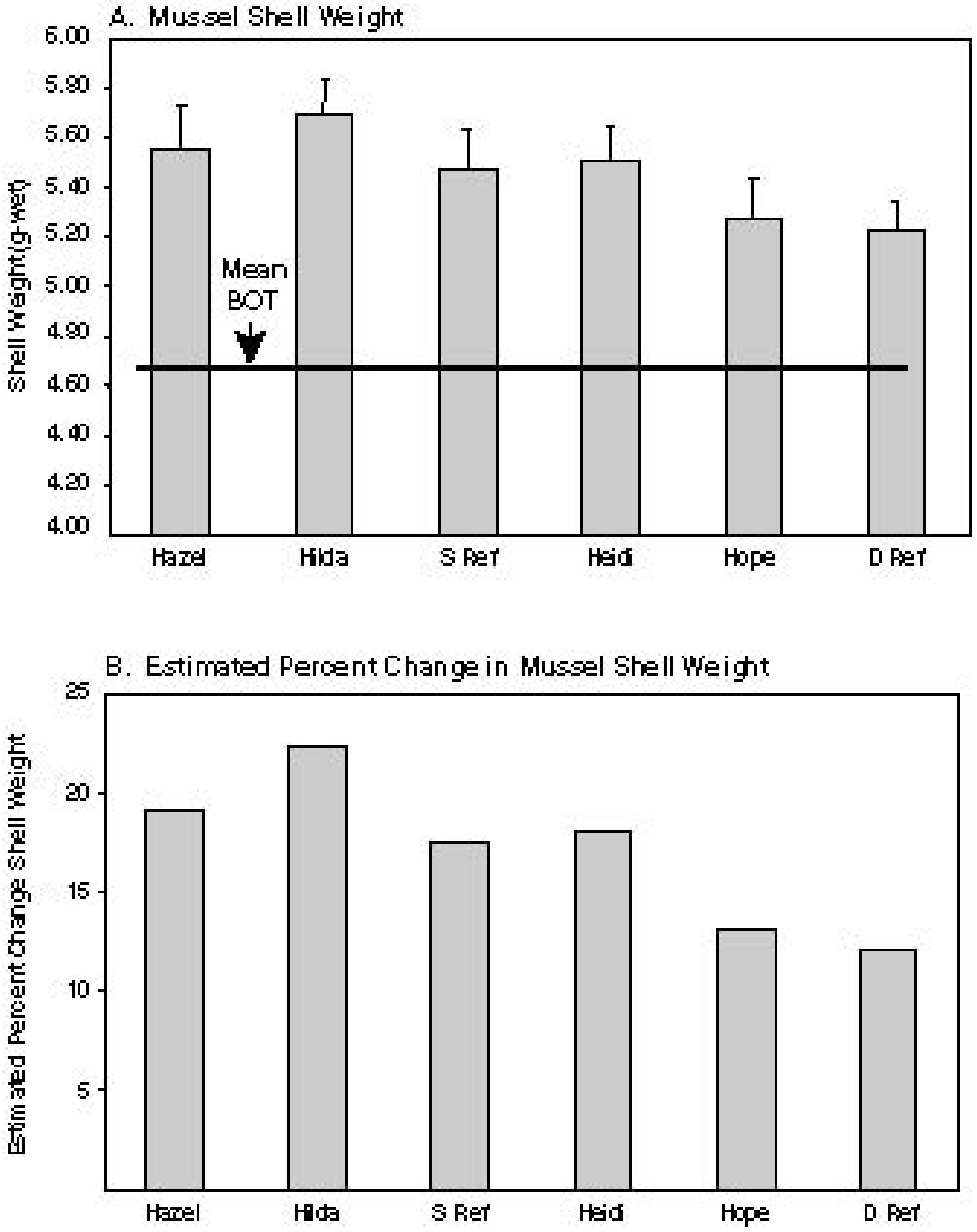

Figure 3.2-4. Mussel Shell Weights

Table 3.2-2. Summary of Mussel Growth Metrics

	Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*Deep Ref*	*Time Zero*	*Mean All Cages*
Percent Survival	90.0%	93.3%	92.1%	92.7%	91.8%	93.2%	na	92.2%
% Change Shell Length	8.3%	9.0%	8.1%	8.2%	6.7%	7.0%	na	7.9%
% Change Weight	29.9%	31.3%	29.7%	28.8%	25.4%	23.9%	na	28.2%
Est % Change in Tissue Weight	42.6%	47.7%	25.8%	24.6%	15.1%	2.0%	na	26.3%
Est % Change in Shell Weight	19.1%	22.3%	17.6%	18.2%	13.2%	12.2%	na	17.1%
Initial Length (mm)								
mean	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.42
min	45.4	47.0	47.0	47.0	47.0	47.1	47.0	45.43
max	55.2	55.4	55.1	55.7	55.7	55.1	55.8	55.80
stdev	2.32	2.27	2.29	2.26	2.30	2.33	2.27	2.29
count	165	165	220	165	165	220	165	1265
95% CI	0.35	0.35	0.30	0.34	0.35	0.31	0.35	0.13
EOT Length (mm)								
mean	55.6	55.9	55.5	55.6	54.9	55.0	na	55.41
min	48.7	49.1	49.3	48.6	47.8	48.0	na	47.82
max	61.7	62.7	64.0	62.3	62.9	62.7	na	64.00
stdev	2.98	2.82	3.07	3.22	3.19	2.79	na	3.01
count	99	154	152	153	101	205	na	864
95% CI	0.59	0.45	0.49	0.51	0.62	0.38	na	0.20
Length Growth Rate (mm/wk)								
mean	0.51	0.55	0.50	0.51	0.42	0.43	na	0.49

Table 3.2-2. Summary of Mussel Growth Metrics

	Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*Deep Ref*	*Time Zero*	*Mean All Cages*
min	-0.02	0.03	-0.12	-0.01	-0.05	-0.01	na	-0.12
max	1.25	1.24	1.21	1.20	1.10	1.27	na	1.27
stdev	0.28	0.29	0.27	0.29	0.26	0.24	na	0.27
count	99	154	152	153	101	205	na	864
95% CI	0.06	0.05	0.04	0.05	0.05	0.03	na	0.02
Initial WAWW (g-wet)								
mean	12.11	12.58	12.22	12.21	12.22	12.31	12.38	12.29
min	7.83	8.20	7.79	8.13	6.96	8.17	8.20	6.96
max	17.32	19.44	18.14	19.17	17.66	17.52	19.07	19.44
stdev	1.87	1.97	1.88	1.79	1.96	1.96	2.04	1.92
count	165	165	220	165	165	220	165	1265
95% CI	0.29	0.30	0.25	0.27	0.30	0.26	0.31	0.11
EOT WAWW (g-wet)								
mean	15.70	16.46	15.83	15.80	15.32	15.18	na	15.71
min	10.82	10.03	11.23	9.91	10.51	9.54	na	9.54
max	22.19	22.84	24.73	24.32	22.75	24.02	na	24.73
stdev	2.45	2.41	2.67	2.53	2.40	2.31	na	2.49
count	99	154	152	153	101	205	na	864
95% CI	0.48	0.38	0.42	0.40	0.47	0.32	na	0.17
WAWW Growth Rate (mg/wk)								
mean	432	466	434	421	369	346	na	408
min	41	-43	-25	-421	-322	1	na	-421
max	982	888	1098	1014	754	953	na	1098

Table 3.2-2. Summary of Mussel Growth Metrics

	Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*Deep Ref*	*Time Zero*	*Mean All Cages*
stdev	177	168	197	201	172	162	na	184
count	99	154	152	153	101	205	na	864
95% CI	34.8	26.5	31.4	31.9	33.6	22.2	na	12.30
Tissue Weight (g-wet)								
mean	4.61	4.78	4.07	4.03	3.72	3.30	3.23	4.03
min	2.74	1.96	2.34	1.81	1.50	1.57	1.40	1.50
max	7.31	8.44	8.02	8.47	7.09	6.59	5.97	8.47
stdev	1.02	1.08	0.99	1.06	1.02	0.81	0.85	1.12
count	99	154	152	153	101	205	165	864
95% CI	0.20	0.17	0.16	0.17	0.20	0.11	0.13	0.07
Shell Weight (g-wet)								
mean	5.55	5.70	5.48	5.51	5.27	5.23	4.66	5.45
min	3.73	3.01	3.31	3.75	3.39	3.21	2.97	3.01
max	8.54	8.24	9.12	8.21	7.98	8.30	7.15	9.12
stdev	0.94	0.89	1.02	0.91	0.85	0.84	0.85	0.92
count	99	154	152	153	101	205	165	864
95% CI	0.19	0.14	0.16	0.14	0.17	0.12	0.13	0.06
Percent Lipids								
mean	8.8%	9.0%	8.2%	7.3%	8.0%	7.0%	6.1%	7.7%
min	8.4%	8.7%	7.9%	6.3%	7.8%	6.9%	6.0%	6.0%
max	9.2%	9.5%	8.7%	8.1%	8.1%	7.1%	6.2%	9.5%
stdev	0.6%	0.4%	0.5%	0.9%	0.2%	0.1%	0.1%	1.1%
count	2	3	3	3	2	3	3	19
95% CI	0.8%	0.5%	0.5%	1.0%	0.3%	0.1%	0.1%	0.5%

Table 3.2-2. Summary of Mussel Growth Metrics

	Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*Deep Ref*	*Time Zero*	*Mean All Cages*
Percent Solids								
mean	18.8%	18.4%	18.8%	17.6%	17.8%	17.8%	20.8%	18.6%
min	18.5%	18.2%	18.0%	16.8%	17.3%	17.5%	20.6%	16.8%
max	19.1%	18.6%	19.7%	18.1%	18.4%	18.1%	21.2%	21.2%
stdev	0.4%	0.2%	0.9%	0.7%	0.8%	0.3%	0.4%	1.2%
count	2	3	3	3	2	3	3	19
95% CI	0.5%	0.2%	1.0%	0.8%	1.1%	0.3%	0.4%	0.5%

Table 3.2-3. Summary of Results from Statistical Analyses of Mussel Growth Metrics

Comparison	*Statistical Result*	*p value*
Survival among all sites	No significant difference	0.359<p< 0.970
Shell length: EOT vs BOT by sites	All sites significantly higher at EOT	p < 0.0001
Shell length: EOT - Shallow sites	No significant difference	p = 0.4425
Shell length: EOT - Deep sites	No significant difference	p = 0.0879
Length Growth Rates: EOT - Shallow sites	No significant difference	p = 0.2651
Length Growth Rates: EOT - Deep sites	Significant difference (Heidi > Deep Ref)	p = 0.0087
WAWW: EOT vs BOT by sites	All sites significantly higher at EOT	p < 0.0001
WAWW: EOT - Shallow sites	Significant difference (Hilda > Shallow Ref)	p = 0.0114
WAWW: EOT - Deep sites	Significant difference	p = 0.0490

Table 3.2-3. Summary of Results from Statistical Analyses of Mussel Growth Metrics

Comparison	*Statistical Result*	*p value*
	(Heidi > Deep Ref)	
WAWW Growth Rates: EOT - Shallow sites	No significant difference	p = 0.2188
WAWW Growth Rates: EOT - Deep sites	Significant difference (Heidi > Deep Ref)	p = 0.0004
Tissue Weight: EOT vs BOT by sites	Significant difference (All sites except Deep Ref > BOT estimate)	p < 0.0001
Tissue Weight: EOT - Shallow sites	Significant difference (Hazel & Hilda > Shallow Ref)	p < 0.0001
Tissue Weight: EOT - Deep sites	Significant difference (Heidi & Hope > Deep Ref)	p < 0.0001
Shell Weight: EOT vs BOT by site	Significant difference (All sites > BOT estimate)	p < 0.0001
Shell Weight: EOT - Shallow sites	No significant difference	p = 0.1159
Shell Weight: EOT - Deep sites	Significant difference (Heidi > Deep Ref)	p = 0.0090
Percent Lipids: EOT vs BOT by site	Significant difference (All sites except Deep Ref > BOT)	p = 0.0002
Percent Lipids: EOT - Shallow site	No significant difference	p = 0.1797
Percent Lipids: EOT - Deep sites	No significant difference	p = 0.3155

Table 3.2-4. Average Metal Concentrations (mg/kg dry wt) in Mussel Tissues (Values of one-half the reporting limit were used for non-detected results to calculate means.)

		SHALLOW			DEEP		
Metal	*Time Zero*	*Hilda*	*Hazel*	*Shallow Reference*	*Hope*	*Heidi*	*Deep Reference*
AG	<0.044	<0.044	0.047	<0.044	<0.044	<0.044	<0.044
Al	94	120	197	184	188	184	236

Table 3.2-4. Average Metal Concentrations (mg/kg dry wt) in Mussel Tissues (Values of one-half the reporting limit were used for non-detected results to calculate means.)

		SHALLOW			DEEP		
Metal	*Time Zero*	*Hilda*	*Hazel*	*Shallow Reference*	*Hope*	*Heidi*	*Deep Reference*
As	7.80	10.4	10.5	11.2	11.1	10.6	11.2
Ba	0.76	1.56	2.40	2.39	2.22	2.31	2.15
Be	0.041	0.046	0.032	0.053	0.034	0.053	0.045
Cd	1.12	8.36	7.18	7.07	6.99	7.62	6.71
Co	0.340	0.694	0.645	0.664	0.595	0.632	0.644
Cr	1.68	2.58	2.69	2.61	4.09	3.77	3.79
Cu	4.87	6.13	6.09	5.95	6.08	5.78	5.76
Fe	129	170	217	231	216	212	273
Hg	0.050	0.052	0.052	0.055	0.068	0.061	0.072
Mo	1.07	3.76	3.86	10.47	4.15	4.66	5.16
Ni	0.927	1.73	1.57	1.78	1.58	1.58	1.76
Pb	0.985	0.498	0.568	0.612	0.653	0.595	0.701
Sb	0.023	0.027	0.023	0.021	0.025	0.024	0.034
Se	5.56	7.33	7.01	7.65	8.44	8.29	8.67
Tl	0.014	0.047	0.046	0.041	0.036	0.039	0.039
V	0.490	1.19	1.05	1.66	0.879	1.039	1.42
Zn	120	128	118	123	146	140	145

U (less than) values of one-half the reporting limit were used to calculate means by site.

J (estimated) values were used as-is for calculating average concentrations.

3.2.3 Tissue Lipids

The tissue lipid content of the test mussels (i.e., shell mound and reference sites) ranged from 6.3 to 9.5% dry weight, whereas the T_0 mussel tissues contained 6.0 to 6.2% dry weight lipids. Tissue lipid concentrations for the shell mound, reference, and BOT mussel samples are compared in box and whisker plots (Figure 3.2-5). For these plots, the top, middle, and bottom horizontal lines represent the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the

vertical lines (whiskers) represent the 10th and 90th percentiles. A one-way ANOVA on the untransformed lipid data indicated statistically significant differences ($p<0.001$) among samples. The power of the test (with alpha set at 0.05) was 1.000, demonstrating that the test provided sufficient statistical sensitivity for distinguishing real differences among sites. The multiple range test (Student-Newman-Keuls) results indicated that the T_0 samples contained significantly lower lipid concentrations that the EOT samples. The mean lipid contents of the shallow shell mound sites generally were higher than those at the deeper shell mound sites. However, there were no significant differences between the shallow or deep shell mound sites and the corresponding reference sites. The higher lipid contents in the EOT mussel tissue samples compared to those in the T_0 samples support the results of the growth analysis (Section 3.2.1), and demonstrate that the end-of-test mussels had accumulated lipid during the exposure period and, therefore, had been actively feeding. A higher lipid content also suggested that mussels did not lose PAHs through spawning. Further, these results support the general conclusion that the test mussels from the shell mound sites were healthy and not stressed as a result of the exposure conditions.

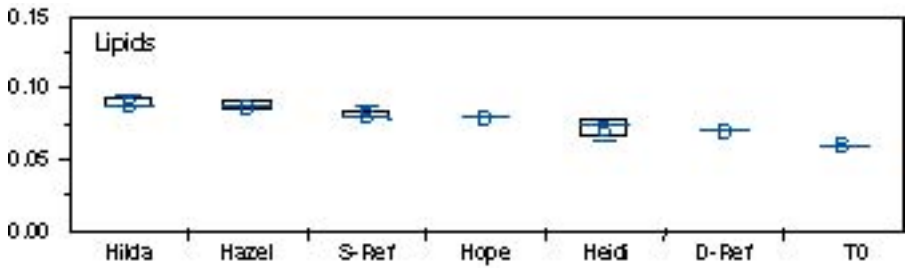

Figure 3.2-5. Box-Whisker Plot of Lipid Concentrations (% dry weight) in Mussel Tissues (The top, middle, and bottom horizontal line represents the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the vertical lines (whiskers) represent the 10th and 90th percentiles.)

3.2.4 Contaminant Bioaccumulation

Metals: Average metal concentrations in the T_0, shell mound, and reference site mussels are listed in Table 3.2-4, and the distributions of concentration values for individual metals at each site are illustrated in box and whisker plots shown in Figures 3.2-6 through 3.2-8. These plots reflect both the within-site replicate variability as well as differences between sites. In most cases, coefficients of variation for replicate metal concentrations were at or below 10%, indicating close agreement among replicate samples and small within-site variability. All of the raw metals concentration data, along with the corresponding quality assurance summaries are provided in Appendix C.

All of the mussel tissue silver values were at or below the reporting limit (U values; less than 0.0445 mg/kg), and large numbers of the beryllium, antimony, and thallium values were below

the reporting limit but above the method detection limits (J values). Therefore, no differences among sites were indicated for these metals. All other metal concentrations were above the respective reporting limits (see Table 2.1-4).

Results from one-way ANOVA and multiple range tests on the mussel tissue metal concentrations are presented in Table 3.2-5. Statistical tests were performed on the untransformed data unless the tests for normality or equal variance failed. In these cases, the data were rank-transformed and tested using a non-parametric (Kruskal-Wallis) analysis of variance and Dunn's multiple range test. For all but a few of the metals, the statistical power values were equal to or greater than 0.8, indicating that tests provided adequate sensitivity for detecting significant differences among sites.

The ANOVA results indicated statistically significant differences ($p<0.05$) among sites for all metals except beryllium and antimony. However, results from the multiple range tests indicated no consistent differences between the shell mound and corresponding reference sites in mussel tissue metal concentrations. The exceptions were higher mercury concentrations in deep reference samples than Heidi shell mound samples, and higher molybdenum in shallow reference samples than in the Hazel and Hilda shell mound samples. Barium concentrations in the shell mound mussels were not significantly different from those in corresponding reference site mussels despite the presence of elevated barium concentrations in shell mound sediments (AMEC, 2002b) and in several of the surface sediments collected within a few hundred meters of the shell mounds (see Section 3.4).

For several metals (aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, nickel, selenium, thallium, vanadium, and zinc), concentrations in the time zero (T_0) mussel tissue samples were significantly lower than those in mussel tissues from one or more of the test sites (i.e., shell mound and/or reference sites). The multiple range test results, indicating a general absence of significant differences between the shell mound and corresponding reference site samples, were not substantially different when the data were re-tested without the T_0 samples. An exception was lead, for which concentrations for the deep reference site samples were significantly higher than those for Heidi shell mound samples, and the shallow reference site samples were significantly higher than those for the Hilda shell mound samples.

Differences between the T_0 and EOT samples in mussel tissue metal concentrations likely were due in part to regional differences in conditions between the collection site for the T_0 mussel samples (Platform Emmy off Huntington Beach) and the shell mound and reference exposure sites off Carpinteria and Rincon. In particular, the T_0 mussels were from water depths well above the bottom, and it is unlikely that they were exposed to the same level of resuspended sediments and/or metal fluxes from bottom sediments as those deployed at the shell mound and reference sites (i.e., within 1 m of the bottom). Additionally, the water temperature data (Section 3.1) strongly suggest

Table 3.2-5. Summary of Results from Statistical Analyses of Mussel Tissue Metals Bioaccumulation Data

Parameter	*Transformation*	*Statistical Result* *Mound Reference Differences*	*p value*
Aluminum	Rank	None (Shell Mound and Reference > T_0)	p = 0.029
Arsenic	None	None (Shell Mound and Reference > T_0)	p < 0.001
Barium	Rank	None	p = 0.046
Beryllium	None	No significant difference	p = 0.156
Cadmium	None	None (Shell Mound and Reference > T_0)	p < 0.001
Cobalt	None	None (Shell Mound and Reference > T_0)	p < 0.001
Chromium	None	None (Shell Mound and Reference > T_0)	p = 0.007
Copper	None	None (Shell Mound and Reference > T_0)	p < 0.001
Iron	Rank	None (Shell Mound and Reference > T_0)	p = 0.018
Mercury	None	Heidi < Deep Reference	p < 0.001
Molybdenum	None	Hilda, Hazel < Shallow Reference	p < 0.001
Nickel	None	None (Shell Mound and Reference > T_0)	p < 0.001
Lead	Rank	None (Hilda < T_0)	p = 0.011
Antimony	Rank	No significant difference	p = 0.174
Selenium	None	None (Shell Mound and Reference > T_0)	p < 0.001
Thallium	None	None (Shell Mound and Reference > T_0)	p < 0.001
Vanadium	None	None (Shell Mound and Reference > T_0)	p = 0.007
Zinc	None	None (Shell Mound and Reference > T_0)	p < 0.001
Lead (w/o T_0)	None	None (Shell Mound and Reference > T_0)	p < 0.001

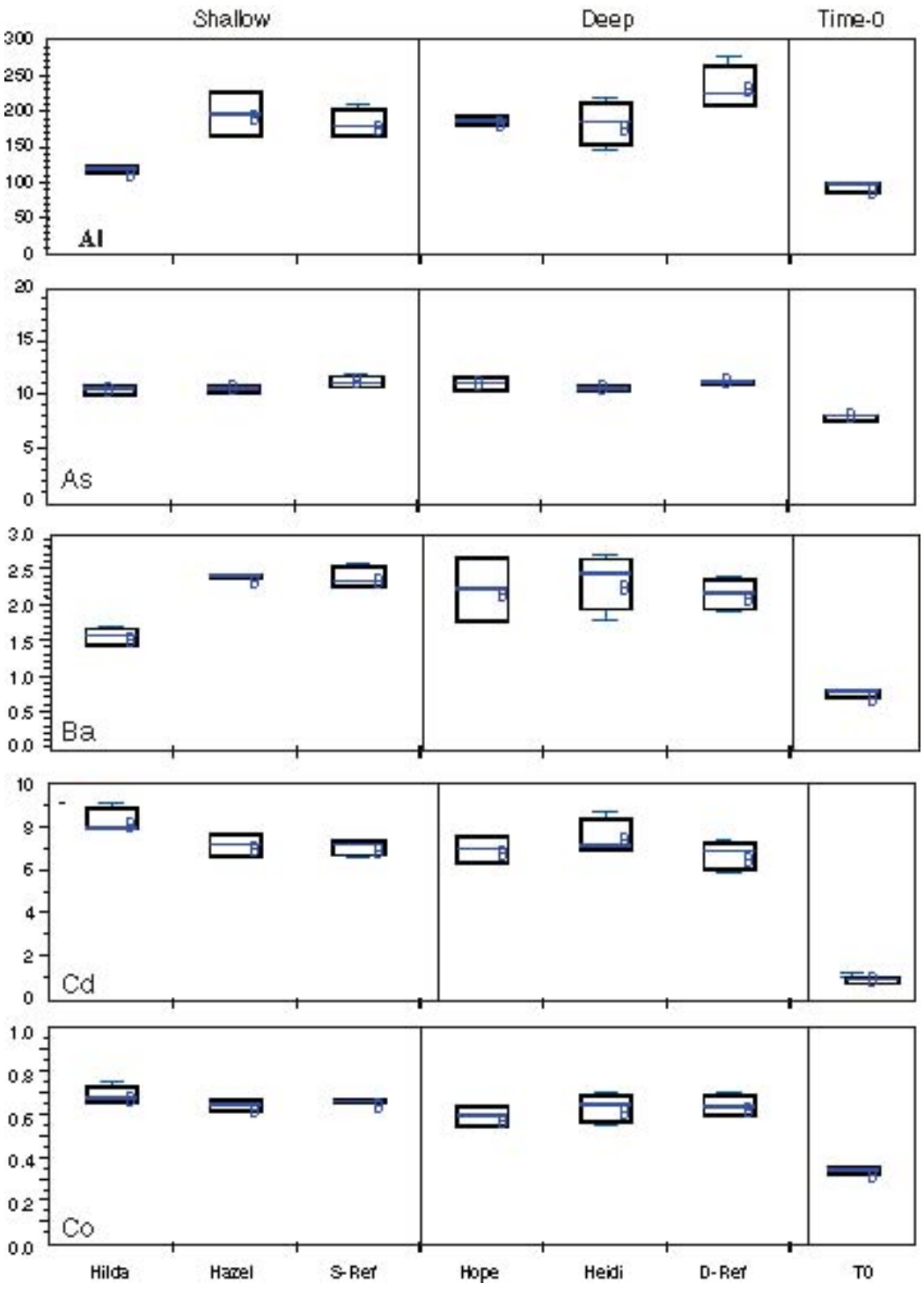

Figure 3.2-6. Box-Whisker Plots of Metal Concentrations (mg/kg dry weight) in Mussel Tissues (The top, middle, and bottom horizontal line represents the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the vertical lines (whiskers) represent the 10th and 90th percentiles.)

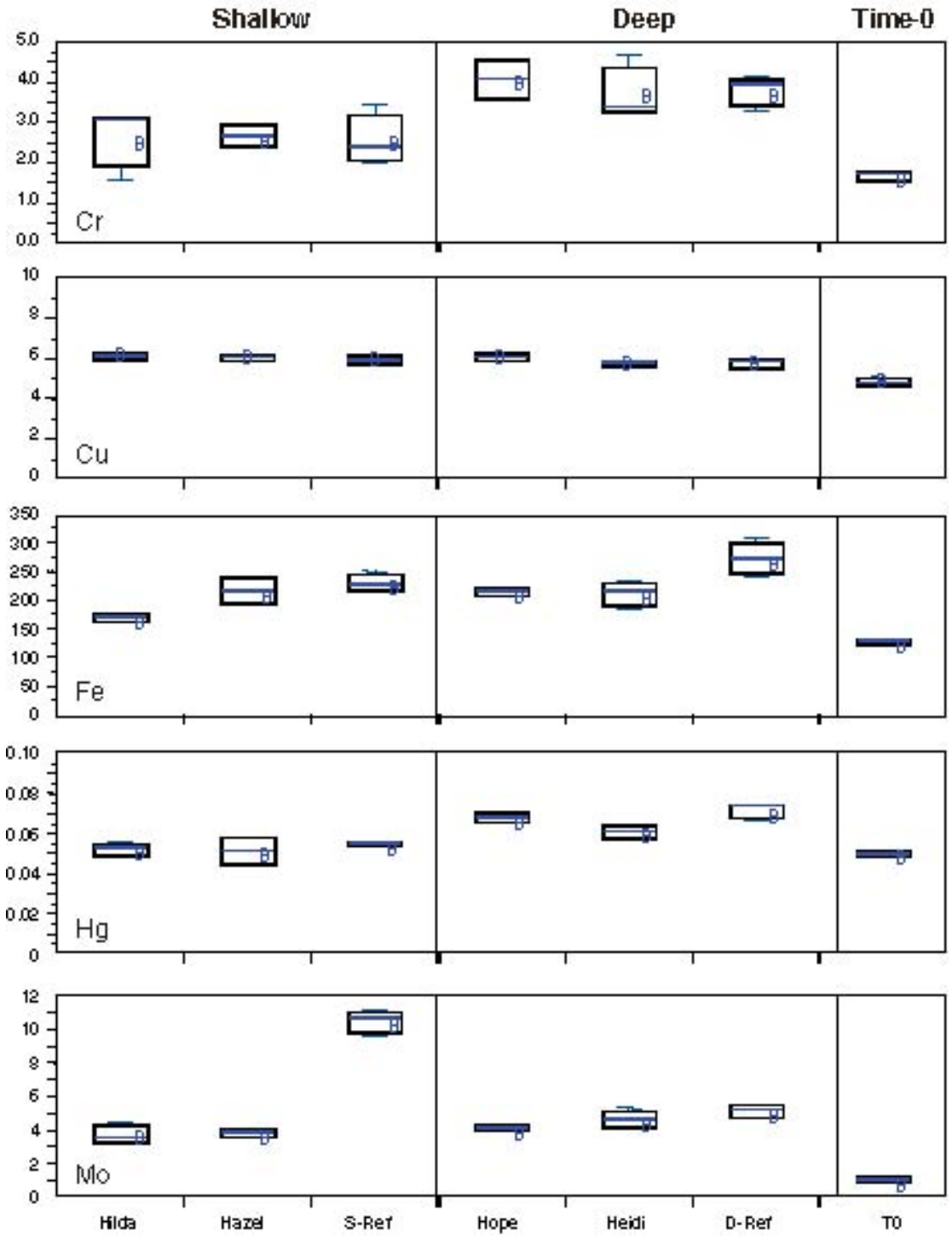

Figure 3.2-7. Box-Whisker Plots of Metal Concentrations (mg/kg dry weight) in Mussel Tissue (The top, middle, and bottom horizontal line represents the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the vertical lines (whiskers) represent the 10th and 90th percentiles.)

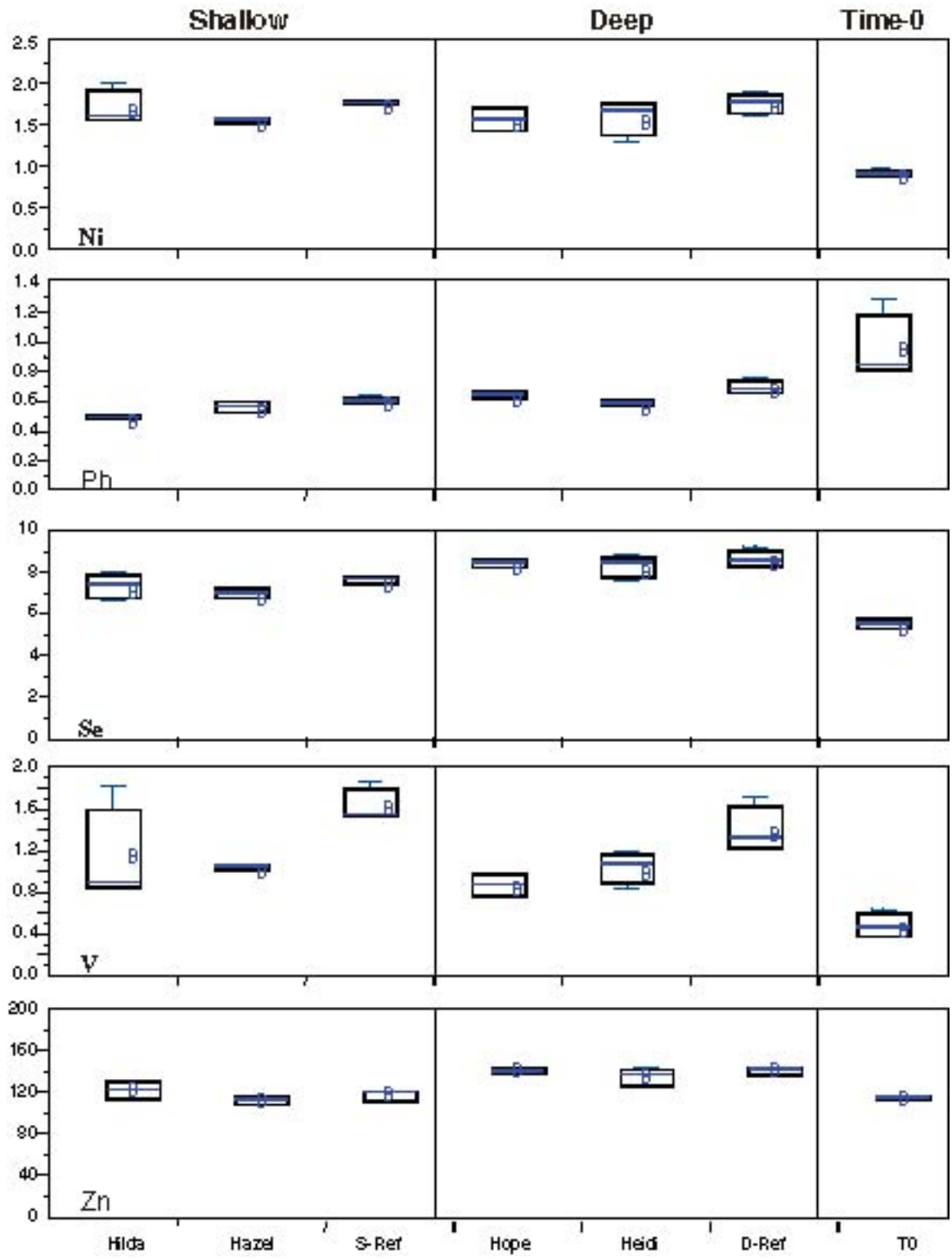

Figure 3.2-8. Box-Whisker Plots of Metal Concentrations (mg/kg dry weight) in Mussel Tissues (The top, middle, and bottom horizontal line represents the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the vertical lines (whiskers) represent the 10th and 90th percentiles.)

that an upwelling event occurred within the area of the shell mounds and reference sites around March 17 and possibly April 1. Upwelling can be a source of elevated concentrations of several metals, particularly cadmium, which are normally depleted in near-surface waters but present at relatively higher concentrations in recently upwelled subsurface
waters (Farrington et al., 1983; Goldberg and Martin, 1983). Consequently, the regional upwelling events probably supplied high metal concentrations to coastal waters, thereby accounting for the elevated concentrations in the test and reference mussel tissue samples.

Reasons for the significantly higher molybdenum concentrations in mussels from the shallow reference site were not apparent. Results from analyses of surface sediments from the shallow reference site (Section 3.4) did not indicate high molybdenum concentrations at this site. The mussel tissue metal results also suggested relatively higher selenium and zinc concentrations in mussels from deep sites compared with those from shallow sites (but no differences between the shell mound and corresponding reference sites). The reasons for these depth-related differences are not apparent.

Chlorinated Pesticides and Polychlorinated Biphenyls: Average concentrations of selected individual and summed pesticides and PCBs in T_0, shell mound, and reference site mussel tissue samples are listed in Table 3.2-6. The parameters listed in the table include most of the chlorinated pesticide and PCB analytes that were present in the shell mound mussel tissue samples at concentrations above the respective reporting limits. Other chlorinated pesticides, such as endrin, heptachlor, and endosulfan, that were not detected in the test mussel tissue samples, are not listed in the table. However, endrin, heptachlor, and endosulfans I and II were detected at concentrations near the respective reporting limits in two of the three T_0 tissue samples.

DDT and related metabolites (DDD and DDE) were the dominant chlorinated pesticides present in the T_0 and shell mound mussel tissue samples. Average concentrations of total DDT (sum of detected o,p′ and p,p′ isomers of DDT, DDE, and DDD) ranged from 27 to 37 ng/g dry weight in the test mussels and 61 ng/g in the T_0 mussels. Chlordanes (alpha and gamma-chlordane and cis and trans-nonchlor), hexachlorocyclohexanes (alpha, beta, gamma, and delta BHCs), and dieldrin also were detected in most or all of the shell mound, reference, and T_0 mussel tissue samples. Average total chlordane and dieldrin concentrations in the T_0 mussels (6.8 ng/g and 0.82 ng/g, respectively) were higher than ranges of average concentrations for the shell mound and reference mussels (2.7-3.7 ng/g and 0.28-0.42 ng/g, respectively), whereas concentrations of total BHC in the test and T_0 mussels were comparable (Figure 3.2-9). The relative proportions of the individual DDT isomers, and the magnitudes of other detected chlorinated pesticides, were consistent in the shell mound, reference, and T_0 mussels and did not indicate any substantial regional differences (i.e., between the collection site and exposure sites).

Table 3.2-6. Average Concentrations (ng/g dry wt) of Pesticides and Polychlorinated Biphenyls in Beginning (T_0) and End-of-Test Mussel Tissues

Pesticides and PCBs		SHALLOW			DEEP		
	Time Zero	*Hilda*	*Hazel*	*Shallow Reference*	*Hope*	*Heidi*	*Deep Reference*
Total DDT	61.02	36.91	29.73	33.94	30.36	27.46	29.87
Total Chlordanes	6.84	3.36	3.50	3.66	3.51	2.74	3.09
Total BHCs	3.41	4.68	3.86	3.87	3.51	3.01	4.15
Dieldrin	0.82	0.28	0.34	0.37	0.42	0.32	0.36
Total PCBs (cong.)	32.26	14.55	13.30	10.81	16.89	13.60	15.82
Aroclor 1254	71.52	42.02	41.43	40.84	46.22	39.47	41.80

Notes: Total DDT represents the sum of the detected o,p′- and p,p′- isomers of DDT, DDE, and DDD; total chlordane is the sum of detected alpha- and gamma-chlordanes and cis- and trans-nonachlor; total BHC is the sum of detected alpha, beta, gamma, and delta hexachlorocyclohexanes; total PCBs is the sum of detected congeners.

U (less than values) considered zero for calculating total concentrations for analyte class; values of one-half the reporting limit were used to calculate means for non-summed parameters.

J (estimated) values were used as-is for calculating total and average concentrations.

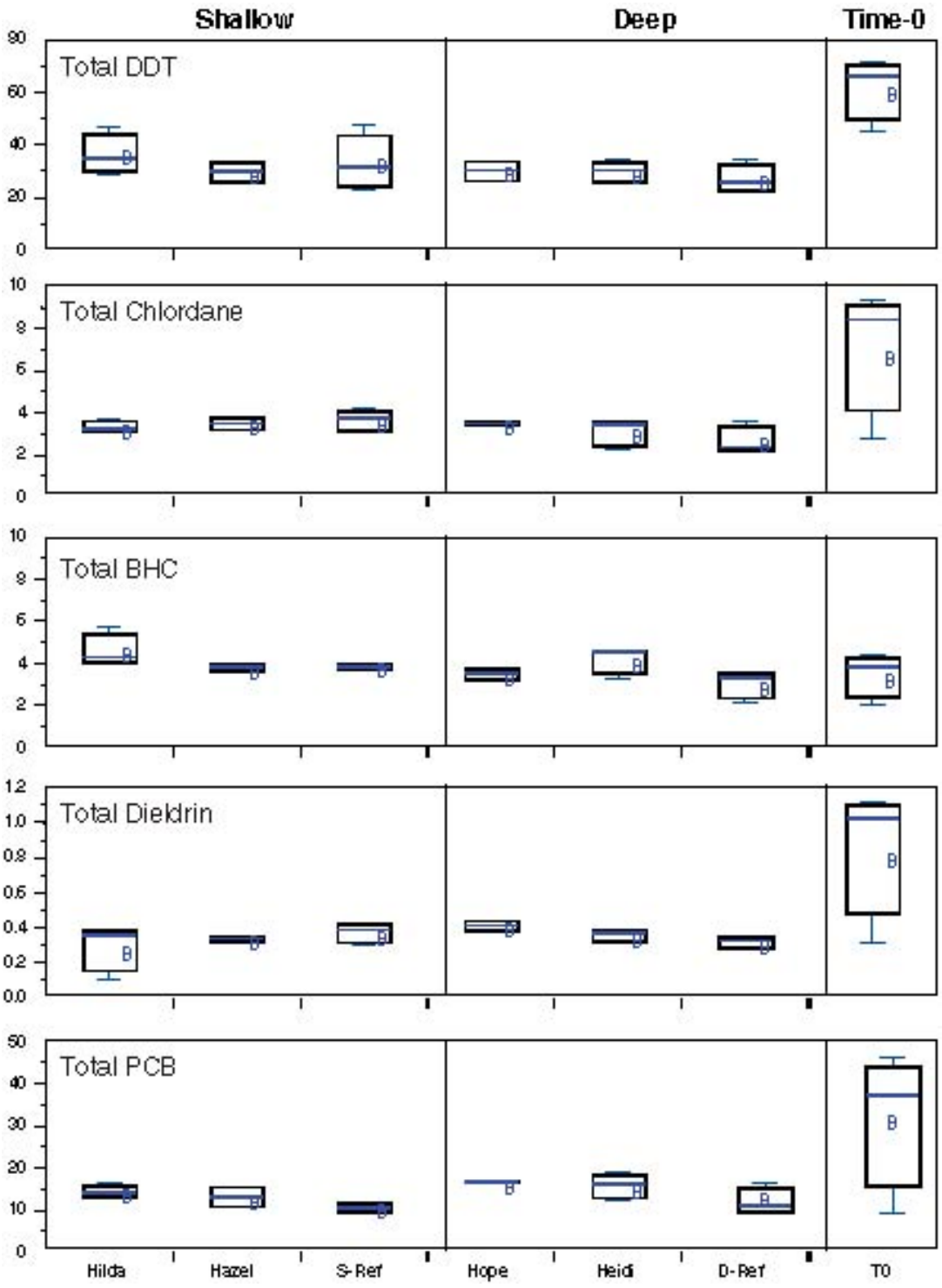

Figure 3.2-9. Box-Whisker Plots of Pesticide and PCB Concentrations (ng/g dry weight) in Mussel Tissues (The top, middle, and bottom horizontal line represents the 75th, 50th, and 25th percentiles, respectively, the symbol within the box represents the mean, and the vertical lines (whiskers) represent the 10th and 90th percentiles.)

Average concentrations of total PCBs (sum of detected congeners) ranged from 11 to 17 ng/g, while PCB concentrations expressed as Aroclor 1254 ranged from 39 to 46 ng/g in the test mussels. Aroclor 1254 was present at detectable levels in mussels from the Heidi shell mound despite the absence of detectable Aroclor 1254 in the shell mound cores (AMEC, 2002b) or in surface sediments near the Heidi shell mound (see Section 3.4). Concentrations of PCBs in the T_0 mussel tissue samples were higher than those in the shell mound and reference mussel samples. For all samples, concentrations of Aroclor 1254 were approximately two to three times higher than the corresponding sums of detected PCB congeners. These differences generally were consistent with results from previous studies (e.g., National Status and Trends Program) that observed that the sum of the detected PCB Aroclors was approximately two times higher than the sum of PCBs expressed as level of chlorination (e.g., O'Connor, 1996).

Proportions of individual PCB congeners in the shell mound, reference, and T_0 mussel tissue samples are shown in Figure 3.2-10. The proportions were calculated by dividing the concentrations of each congener by the sum of all detected congeners in each sample. The figure illustrates that the compositions of the PCBs were relatively consistent among the shell mound and reference site samples, including the Heidi shell mound samples, and that five of the pentachloro- (Cl5) through heptachloro- (Cl7) biphenyls (101, 118, 138, 153, and 187) accounted for 74 to 84% of the corresponding summed PCB concentrations. By comparison, the T_0 mussel tissue samples contained some of the lower (Cl2 and Cl3) and higher (Cl10) chlorinated biphenyls that were absent or not abundant in the shell mound and reference site mussels, and the five main congeners accounted for a relatively lower proportion (67%) of the total PCB concentration. These differences between the T_0 and test mussels in the PCB fingerprints could reflect regional differences in the exposure conditions and/or selective loss of the lower chlorinated biphenyls from the test mussels (e.g., Langston, 1978).

Mean concentrations of most pesticide groups and PCBs, other than total BHCs, were higher in the T_0 mussel tissue samples than in any of the shell mound or reference site mussel samples (Figure 3.2-9). However, these differences were statistically significant only for total DDT (Table 3.2-7). For all other analytes, ANOVA results were not statistically significant ($p > 0.05$). Further, there were no statistically significant differences between the shell mound and corresponding reference site samples for any of the pesticide or PCB analytes. While the presence of Aroclor 1254 in the test mussel tissue samples was consistent with the presence of detectable Aroclor 1254 both in the shell mound sediments (AMEC, 2002b) and in surficial sediments adjacent to the shell mounds (except at the Heidi shell mound; see Section 3.4), the results from this study did not indicate any significant differences between the shell mound and reference site samples that suggest greater exposure or accumulation of PCBs near the shell mounds.

These results were also consistent with the absence of detectable PCBs in the SPMD samples from the shell mound and reference sites (see Section 3.3)

Differences between the T_0 mussel tissue samples and shell mound and reference site mussel samples in total DDT concentrations likely reflected regional differences in ambient DDT levels and the proximity of the collection site (Platform Emmy) to a known

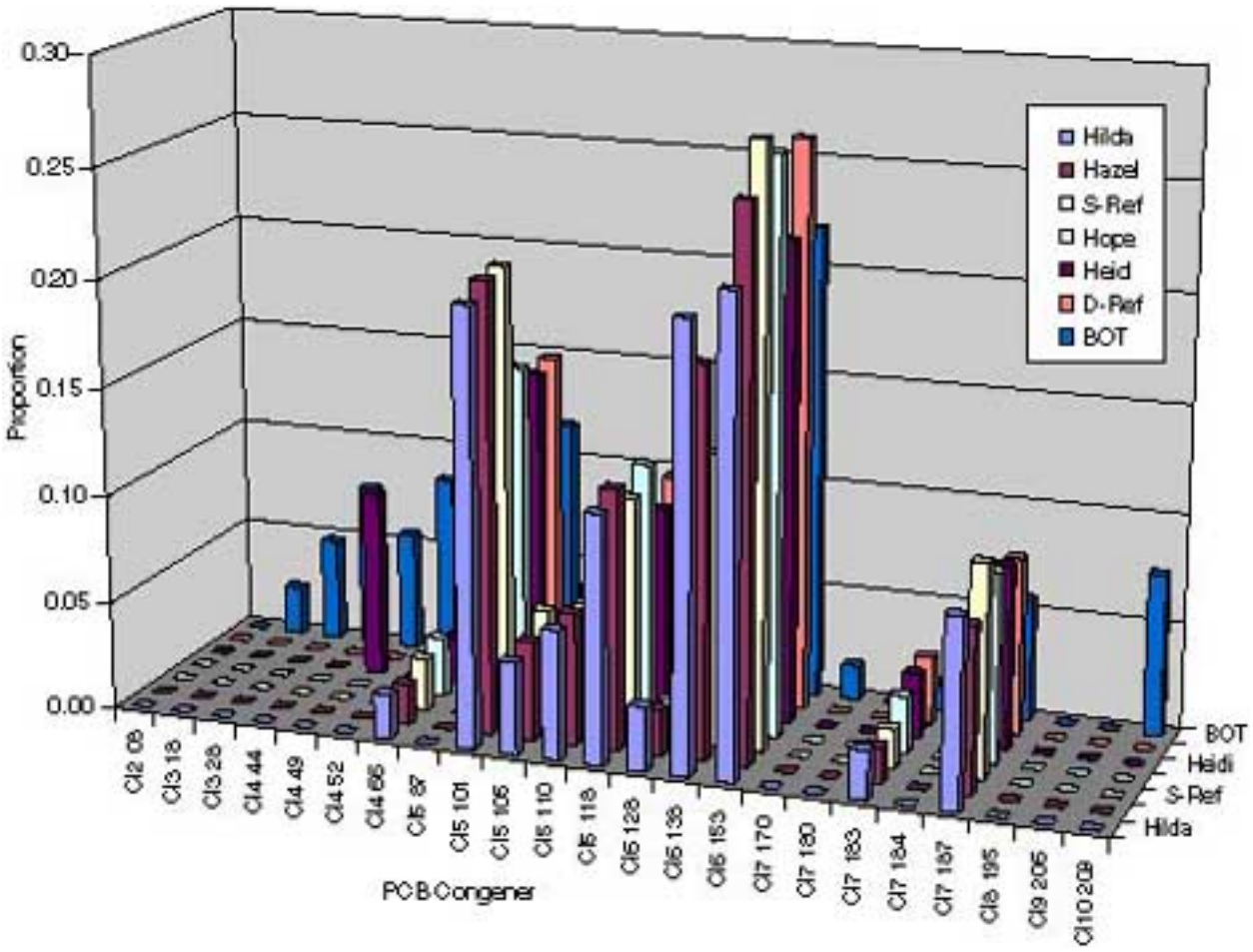

Figure 3.2-10. Proportions by Weight of Individual PCB Congeners in Mussel Tissues from the Shell Mound and Reference Sites and Beginning-of-Test (BOT) Samples

Table 3.2-7. Summary of Results from Statistical Analyses of Mussel Tissue Pesticide, PCB, and PAH Bioaccumulation Data

Parameter	*Transformation*	*Statistical Result* *Mound Reference Differences*	*p value*
Total DDT	None	None (Shell Mound and Reference < T_0)	p = 0.012
Total Chlordanes	Rank	No significant difference	p = 0.652
Total BHC	None	No significant difference	p = 0.281
Dieldrin	Rank	No significant difference	p = 0.465
Total PCB (congeners)	Rank	No significant difference	p = 0.306

Table 3.2-7. Summary of Results from Statistical Analyses of Mussel Tissue Pesticide, PCB, and PAH Bioaccumulation Data

Parameter	*Transformation*	*Statistical Result Mound Reference Differences*	*p value*
Total PCB (Aroclor 1254)	Rank	No significant difference	p = 0.927
Total PAH	None	None (Shell Mound and Reference < T_0)	p = 0.001
Total N	None	No significant difference	p = 0.127
Total F	None	No significant difference	p = 0.671
Total P/A	Rank	No significant difference	p = 0.112
Total DBT	Rank	No significant difference	p = 0.130
Total Fl/Py	None	None (Shell Mound and Reference < T_0)	p = 0.005
Total C	Rank	No significant difference	p = 0.056

source for DDT (i.e., contaminated sediments on the Palos Verdes Shelf). Spatial differences in pesticide and PCB concentrations normalized to the corresponding tissue lipid contents were also tested using ANOVA. These results were similar to those for non-normalized concentration data, and indicated no statistically significant differences between the shell mound and corresponding reference sites.

Polycyclic Aromatic Hydrocarbons: Average concentrations of total PAHs and selected PAH groups in T_0, shell mound, and reference site mussel tissue samples are listed in Table 3.2-8. The average total PAH concentrations in the shell mound and reference site mussel tissue samples ranged from 63.5 to 80.7 ng/g dry weight (Figure 3.2-10), compared to the average total PAH concentration of 162 ng/g for the T_0 mussel samples.

The low and high molecular weight PAHs were divided into the following classes because of the relative potential for accumulation and toxic effect of each class: naphthalenes (N); fluorenes (F); dibenzothiophenes (DBT); phenanthrenes-anthracenes (P/A); fluoranthenes-pyrenes (Fl/Py); chrysenes (C); and other PAHs. These classes show the differential composition of PAHs across stations. The T0 mussels had higher concentrations of each of these PAH classes than shell mound mussels. For the deployed mussels, the composition of PAH was similar from station to station. In all deployed mussels, the phenanthrenes/anthracenes were the largest fraction, ranging from 28.62 to 38.83 ng/g dw, accounting for 38.1 to 49.3% of the total PAHs measured (Table 3.2-9). Dibenzothiophenes were the second largest fraction, followed by fluoranthenes/pyrenes and naphthalenes. Fluorenes and chrysenes were present at the lowest concentrations.

Table 3.2-8. Average Concentrations (ng/g dry wt) and Component Ratios of Polycyclic Aromatic Hydrocarbons in Beginning (T0) and End-of-Test Mussel Tissues

		SHALLOW			DEEP		
Metal	*Time Zero*	*Hilda*	*Hazel*	*Shallow Reference*	*Hope*	*Heidi*	*Deep Reference*
Total Naphthalene	15.56	7.64	6.95	7.84	9.18	11.48	12.00
Total Fluorene	2.85	3.40	2.72	3.25	3.15	3.24	2.83
Total Phenanthrene/ Anthracene	55.4	23.8	38.8	32.2	28.6	31.7	30.2
Total Dibenzothiophene	30.6	9.09	13.9	11.0	11.7	10.4	11.5
Total Fluoranthene/ Pyrene	34.9	17.1	12.8	11.6	11.3	5.68	1.43
Total Chrysene	16.3	3.09	4.48	2.89	2.46	1.41	2.08
Total PAH	162.8	65.8	80.7	70.0	67.6	65.3	63.5
MP/P	0.72	0.71	0.68	0.73	0.57	0.59	0.52
Fl/Py	1.55	0.84	0.79	0.76	0.78	0.83	0.85

Notes: Total naphthalene is the sum of detected C_0 through C_4 naphthalenes; total fluorenes is the sum of C_0 through C_3 fluorenes; total phenanthrene/anthracene is the sum of phenanthrene, anthracene, and C_0 through C_4 phenanthrene/anthracenes; total dibenzothiophene is the sum of detected C_0 through C_3 dibenzothiophenes; total fluoranthene/pyrene is the sum of detected C_0 through C_3 fluoranthene/pyrene; total chrysene is the sum of detected C_0 through C_4 chrysenes; MP/P is the ratio of 1-methyl phenanthrene:phenanthrene; Fl/Py is the ratio of fluoranthene:pyrene.

U (less than values) considered zero for calculating total concentrations for analyte class; values of one-half the reporting limit were used to calculate means for non-summed parameters.

J (estimated) values were used as-is for calculating total and average concentrations.

PAHs derived from petrogenic sources (i.e., crude oil and its refined products) are characterized by their distributions of alkylated homologs of naphthalene, fluorene, phenanthrene, dibenzothiophene, and chrysene, where the parent PAH for each series is least abundant (Page et al., 1995). Combustion-related sources produce a PAH distribution dominated by the parent compounds of the 3-, 4-, and 5-ring PAHs and fluoranthene and pyrene, and are referred to as pyrogenic PAHs. PAHs derived from biogenic sources (i.e., PAHs produced by bacterial modification of recent inputs of organic matter) are characterized by the presence of perylene.

Although some PAHs can be both pyrogenic and petrogenic, a general characterization of PAHs accumulated by aquatic organisms can be achieved using the following equations:

[Pyrogenic PAHs] = sum of 17 EPA priority PAHs*

[Biogenic PAHs] = [perylene]

[Petrogenic PAHs] = [total PAH] - [pyrogenic + biogenic]

*U.S. Environmental Protection Agency; Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(ah)anthracene, Dibenzothiophene, Fluoranthene, Fluorene, Indeno(123-cd)pyrene, Naphthalene, Phenanthrene, Pyrene

The PAHs measured in mussel tissues retrieved from the shell mounds appeared to be primarily petrogenic. Concentrations ranged from 48.92 to 74.52 ng/g dw, and accounted for 77 to 82% of the PAHs measured (Table 3.2-10). Only one sample from the deep reference site contained biogenic PAHs, and these were present at extremely low concentrations. Approximately 20% of the PAHs were characterized as pyrogenic. Although the concentrations for the T_0 mussels were higher than the deployed mussels, the distribution among the three categories was similar.

The compositions of PAHs in all shell mound and reference site mussel samples were similar (Figure 3.2-11), and indicated primary contributions from petroleum compared to combustion sources. Similarly, the alkyl homolog distributions did not indicate any substantial differences among the shell mound and reference sites that might otherwise reflect varying source inputs or the degree of environmental weathering. This is consistent with the relatively uniform values for component ratios such as methyl-phenanthrene to phenanthrene (MP/P) and fluoranthene to pyrene (Fl/Py) (Table 3.2-8), which are indicators of petrogenic and pyrogenic sources.

Results of the one-way ANOVA and multiple range tests indicated significantly higher ($p<0.001$) total PAH concentrations in the T_0 mussel tissue samples compared with those of all shell mound and reference site mussel samples. Differences between the T_0 sample and the shell mound and reference site mussel samples for summed concentrations of fluoranthenes/pyrenes also were significantly different, whereas no statistical differences were apparent for other PAH classes. Furthermore, concen trations of total PAH, and individual PAH classes (e.g., total naphthalenes), in the shell

Table 3.2-9. Concentration by PAH Class (ng/g dw) and Percent of Total PAH

		Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*DeepRef*	*TimeZero*	*w/o HildaOutlier*
Concentration (ng/g dw)									
Naphthalenes									
	Replicate 1	NR	9.97	6.95	13.16	7.29	10.02	21.41	9.966
	Replicate 2	6.71	7.84	8.97	10.23	11.06	8.33	16.15	7.835
	Replicate 3	7.18	5.14	7.60	11.07	NR	17.67	9.12	OE
	Mean	**6.95**	**7.65**	**7.84**	**11.48**	**9.18**	**12.00**	**15.56**	**8.90**
	St Dev	0.34	2.42	1.03	1.51	2.66	4.98	6.17	1.51
	n	2	3	3	3	2	3	3	2
Fluorenes									
	Replicate 1	NR	3.61	2.72	3.65	2.50	2.90	3.25	3.608
	Replicate 2	2.50	2.94	4.04	3.10	3.80	2.61	3.09	2.942
	Replicate 3	2.93	3.65	2.98	2.98	NR	2.99	2.21	OE
	Mean	**2.72**	**3.40**	**3.25**	**3.24**	**3.15**	**2.83**	**2.85**	**3.27**
	95% CI	0.43	0.45	0.79	0.41	1.28	0.23	0.63	0.65
	n	2	3	3	3	2	3	3	2
Dibenzothiophenes									
	Replicate 1	NR	10.50	12.39	10.85	12.06	12.76	30.18	10.501
	Replicate 2	12.45	16.62	11.98	10.59	11.29	8.12	34.33	16.625
	Replicate 3	15.32	0.00	8.59	9.61	NR	13.70	27.40	OE
	Mean	**13.88**	**9.04**	**10.99**	**10.35**	**11.67**	**11.53**	**30.63**	**13.56**
	95% CI	2.81	9.51	2.36	0.73	0.75	3.38	3.95	6.00
	n	2	3	3	3	2	3	3	2
Phenanthracenes-Anthracenes									
	Replicate 1	NR	29.42	38.26	30.75	27.48	29.96	57.02	29.419
	Replicate 2	37.56	40.05	28.59	35.06	29.76	26.51	58.18	40.050
	Replicate 3	40.10	2.06	29.68	29.19	NR	34.05	51.14	OE
	Mean	**38.83**	**23.84**	**32.18**	**31.67**	**28.62**	**30.17**	**55.45**	**34.73**

Table 3.2-9. Concentration by PAH Class (ng/g dw) and Percent of Total PAH

		Hazel	*Hilda*	*Shallow Ref*	*Heidi*	*Hope*	*DeepRef*	*TimeZero*	*w/o HildaOutlier*
	95% CI	2.48	22.18	6.00	3.44	2.24	4.27	4.27	10.42
	n	2	3	3	3	2	3	3	2
Fluoranthene/Pyrene									
	Replicate 1	NR	24.59	15.90	2.84	7.90	0.00	40.24	24.592
	Replicate 2	2.70	22.97	3.21	2.47	14.66	1.97	32.40	22.975
	Replicate 3	23.00	3.85	15.66	11.72	NR	2.32	32.07	OE
	Mean	**12.85**	**17.14**	**11.59**	**5.68**	**11.28**	**1.43**	**34.90**	**23.78**
	95% CI	19.89	13.05	8.22	5.93	6.62	1.41	5.23	1.58
	n	2	3	3	3	2	3	3	2
Chrysenes									
	Replicate 1	NR	4.59	3.79	1.32	3.20	1.65	17.54	4.593
	Replicate 2	4.13	4.66	3.38	1.62	1.72	1.47	20.02	4.663
	Replicate 3	4.84	0.00	1.50	1.29	NR	3.12	11.31	OE
	Mean	**4.48**	**3.09**	**2.89**	**1.41**	**2.46**	**2.08**	**16.29**	**4.63**
	95% CI	0.70	3.02	1.38	0.21	1.46	1.02	5.08	0.07
	n	2	3	3	3	2	3	3	2
Percent Distribution by Class (mean by station)									
Naphthalenes		8.8%	17.4%	11.5%	17.6%	13.4%	18.4%	9.3%	9.9%
Fluorenes		3.4%	10.1%	4.8%	5.0%	4.6%	4.6%	1.7%	3.7%
Dibenzothiophenes		17.4%	9.9%	15.8%	15.9%	17.5%	18.1%	18.9%	14.8%
Phenanthracenes/ Anthracenes		49.3%	29.7%	45.9%	48.6%	42.5%	48.2%	34.4%	38.1%
Fluoranthenes/Pyrenes		14.2%	25.7%	16.0%	8.6%	16.3%	2.3%	21.6%	26.4%
Chrysenes		5.6%	3.4%	4.1%	2.2%	3.8%	3.2%	9.9%	5.1%
Other		1.3%	3.9%	1.8%	2.2%	1.9%	5.3%	4.1%	1.9%
Note: NR = cage not retrieved; OE = outlier excluded									

mound tissue samples were not significantly different ($p>0.05$) from those in the corresponding reference site samples.

The PAH concentration data were converted to content (ng PAH/mussel) to determine the effects of mussel growth on uptake (Table 3.2-11). Results for PAH content were similar to those for PAH concentrations, except that high molecular weight (HMW) PAHs in Hilda mussel tissues were not significantly different from the T_0 concentration.

The content data provides a means to account for possible dilution of PAHs due to rapid increase in mussel soft tissue. As discussed, mussels at some sites had significant increases in soft tissue when compared to their respective reference site. The PAH content data showed trends similar to the concentration data, suggesting no bias to the tissue chemistry results due to increases in tissue mass. Similarly, lipid normalization did not alter the relationships between EOT and T_0 content, or among shell mounds and reference sites. Although mussels had higher lipid contents after the deployment period (see Section 3.2.2), the increase in lipids did not significantly affect the results.